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Faraday Ring Ammeter for Measurements of Ambient Ionospheric Currents

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In this paper, we will describe plans for implementing a new design of a Faraday Ring Ammeter, an optical fiber device for the measurement of electric currents in space plasmas. A prototype version of the Faraday Ring Ammeter (FRA) was developed by the University of New Hampshire and flown on the sounding rocket mission Auroral Turbulence.

Right now, direct measurements of currents are notably lacking in our data sets and specific open questions in auroral physics is the relationship between fine-scale (100's-m) current structures and wave-particle interactions. Recent improvements in optoelectronics technology development at JPL could significantly boost space plasma measurements in upcoming planetary missions. Such missions include Solar Probe, Jupiter Polar Orbiter, and Europa missions. For instance, the Jovian system involves an extremely complicated magnetosphere with many sources and sinks, resulting in complex plasma current patterns.

These currents hold the clues to energy transport in the magnetosphere and the resulting processes, such as the Jovian aurora. Conventional plasma instrumentation provides information on particle fluxes, but not the actual currents themselves; these must be deduced by modeling. Hence, the direct measurement of plasma current by the Faraday ring would provide, for the first time, the information needed to understand details of the dynamics of the Jovian (or other planets) magnetosphere and ionosphere.

We show that information gained from the prototype ammeter, together with recent advances in optical technology, will allow us to develop a much more sensitive FRA for space flight applications. We believe we can improve the sensitivity by several orders of magnitude, eventually making possible remote measurements of current density down to the $5\mu A/m^2$ level. The demonstration of this sensitivity level will be a significant improvement for ionospheric measurements.